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Associations between Health Behaviors and Adolescents Life Satisfaction Using Structural Equation Modeling (SEM)

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by

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Abstract

Associations between Health Behaviors and Adolescents Life Satisfaction Using Structural Equation Modeling (SEM)

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Life satisfaction is an important indicator in suicidal behavior. The purpose of this study was to investigate the influences of health-related behaviors on adolescent life satisfaction using structural equation modeling (SEM). Data were obtained from the Health Behavior in School-Age Children (HBSC), 2001-2002. Because of the complex nature, SEM was preferred to be used over regression models in the present study. The results indicated that good eating habits and high scores of self-reported health played the greatest roles in promoting life satisfaction. The effects of both factors on life satisfaction were also mediated by academic achievement. Physical activity was a positive predictor of life satisfaction, but its effect appears to be mediated by health and academic achievement, rather than affecting life satisfaction directly. Moreover, physical activity was positively associated with good eating habits. These results generated from SEM were also compared with that from multiple linear regressions. Slight differences in the standardized coefficients for the total effects between SEM and regression models were detected due to the existing latent variable in SEM, but the general proportion variance

accounted for in each outcome variable were similar across the two analyses. In summary, although there were some limitations for the study design and the building of the model, this study suggested that good habits with respect to diets may be beneficial for improvements in health and academic achievement, which in turn lead to positive scores of adolescent life satisfaction. High frequent physical activity and low BMI were poor but acceptable predictors of life satisfaction.

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Introduction

The prevalence of suicidal ideation and attempts among youth is increasingly high in recent decades. Life satisfaction is a crucial factor associated with suicidal behavior. Research findings have demonstrated that life satisfaction gradually reduces with the onset and progression of adolescence all over the world (Chang, McBride-Chang, Stewart, & Au, 2003; Suldo & Huebner, 2004). In recent years, there is growing interest in studying the influences of various factors on life satisfaction. With regard to the adolescent population, a lot of research has focused on the adolescent's academic achievement and their health conditions. However, these two factors are not sufficient to reflect psychological aspects of their life quality. Also, limited information is known about the effect of health behaviors on their life satisfaction. Structural equation modeling (SEM) is a statistical method that allows for the analysis of complex relationships among multiple independent and dependent variables simultaneously. It combines characteristics of multiple regression, path analysis, and confirmatory factor analysis to build up a comprehensive structure. Therefore, SEM was used in this study to investigate the relationships among health behaviors, health, academic achievement, and life satisfaction.

Literature review

Overview

Nowadays, suicide is the third leading cause of death for people ages 10-24 years and accounts for about 20% of all deaths annually. Of all reported suicides in this age group, 14.5% of students who are in 9th to 12th grades in the U.S. have reported suicidal ideation and 6.9% reported at least one suicide attempt in the 2000s (Cash & Bridge, 2009). Approximately sixteen percent of high school students have seriously considered attempting suicide. Therefore, suicide is a major problem in public health for adolescents. Life satisfaction is an indicator of subjective well-being (Horley, 1984). A 20-year follow-up study showed that life dissatisfaction had a long term effect on the potential risk of suicide partly via poor health behavior (Koivumaa-Honkanen et al., 2001). This conclusion was also in agreement with a study conducted in older adult population (Steptoe, Deaton, & Stone, 2015). Generally, life dissatisfaction is an indicator of adolescent suicide. It is also considered an early sign of future mental problems and risk for suicidal behaviors in adults. Adolescence, as a transition phase from childhood to adulthood, is experiencing physical, psychological, and social changes. It was found that those going through adolescence (14-16 years) and young adulthood (25-34 years) developed the most impairment in life satisfaction (Morganti, Nehrke, Hulicka, & Cataldo, 1988). Therefore, more attention on adolescent's life satisfaction and the potential related factors should be paid.

Life satisfaction and the potential factors

Quality of life contains objective and subjective aspects. The objective perspective is concluded from external conditions, like networks, income, and housing quality, etc. On the contrary, the subjective perspective is an internal judgment about an individual's quality of life. Simply reporting doing well or low levels of pathological symptoms is not adequate to indicate the quality of one's life. In the early 1990s, Cowen and colleague suggested that life satisfaction should be included in any assessment battery to capture well-being comprehensively in youth (Cowen, 1991, 1994). Life satisfaction is a good indicator of subjective well-being. It is defined as an "overall judgment that one's life is a good one" (Diener, 1984). As a cognitive component of subjective well-being, high life satisfaction is associated with optimal mental health and good adaptations, whereas low life satisfaction is related to social, psychological, and health behavior problems. Life satisfaction should be differentiated from other psychological constructs such as self-esteem. Self-esteem refers to one's overall evaluation of behaviors and personal characteristics, whereas life satisfaction is more comprehensive in that it contains self-esteem and cognitive judgments (Huebner, Funk, & Gilman, 2000).

Across the adult life span, previous studies have showed a U-shaped trajectory in life satisfaction from age 18 to 79 years (Blanchflower & Oswald, 2008; Stone, Schwartz, Broderick, & Deaton, 2010). More attention to life satisfaction should be given to the adolescents due to the high rate of suicide.

Several studies have examined the potential influences on adolescent life satisfaction. This effect seems to be partially mediated via health-related behaviors and social situations. Lines of evidence have found that substance abuse, such as alcohol and drug use, linked with life dissatisfaction and contributed to a risk of suicide substantially (Brent, Baugher, Bridge, Chen, & Chiappetta, 1999; Schilling, Aseltine, Glanovsky, James, & Jacobs, 2009; Shaffer et al., 1996). Family factors also partially account for adolescent suicide. For example, family history of suicidal behavior, loss of a parent, and poor quality of the parent-child relationship resulted in a higher risk of suicidal behavior in young adults (Bridge, Goldstein, & Brent, 2006). An early study reported that self-concept was positively associated with life satisfaction in adolescence. This study also showed that the relationship with parents dominated the prediction of life satisfaction (Leung & Leung, 1992). Moreover, bullying, as another important factor, has been widely investigated. Boys who were both bullies and victims and girls who were victims only are more likely to exhibit suicidal behaviors than those who were neither bullies nor victims (Barker, Arseneault, Brendgen, Fontaine, & Maughan, 2008; Klomek et al., 2009). Some other factors were also reported, such as internet use, sexual orientation, depression, and race, etc. Boys tend to have higher self-esteem and life satisfaction than girls (Moksnes & Espnes, 2013). Also self-esteem was positively related to the adolescents' life satisfaction regardless of gender and age.

During the period of childhood and adolescence, academic achievement is a crucial criterion in today's society to determine one's accomplishments or failures.

However, in order to evaluate one's success in other multiple life domains, academic achievement is not sufficient. Instead, life satisfaction is significant in explaining individual's reactions to different life circumstances and challenging situations. A lot of theories support the positive relationship between academic achievement and life satisfaction. In reality, however, the research on these associations has revealed conflicting results. Therefore, it is necessary to examine the relationship between academic achievement and life satisfaction.

Overweight and obesity

A recent study demonstrated that adolescents who showed lower life satisfaction were overweight and obese (Forste & Moore, 2012). Childhood obesity has more than quadrupled in adolescents in the past 30 years. Research found that the percentage of obesity in adolescents aged 12-19 years increased from 5% in 1980 to about 21% in 2012 (Ogden, Carroll, Kit, & Flegal, 2014). In 2012, more than one third of children and adolescents were overweight or obese (Ogden et al., 2014). Obesity is likely to contribute to diabetes, cardiovascular disease, and joint problems, etc. Previous findings demonstrated that 70% of obese adolescents had at least one risk factor for the above problems (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Li, Ford, Zhao, & Mokdad, 2009). Indeed, obesity itself is an independent risk factor for cardiovascular disease to increase morbidity and mortality (Raj & Kumar, 2010). Thus, such a high prevalence of adolescents who are overweight and obese becomes a major public health issue in developed countries. As mentioned earlier, overweight and obese in adolescents are tightly associated with life satisfaction by self-perceptions, family, and peers

relationships (Forste & Moore, 2012), so it is important to examine factors controlling overweight/obese. In contrast, age and gender have less of an influence on the relationship between being overweight and life satisfaction, though overweight girls showed a lower trend on life satisfaction than overweight boys because the external pressure to be thin is perceived to be greater for girls than boys (Forste & Moore, 2012).

BMI is very commonly used to identify adolescents who are overweight or obese. Early research indicates a strong relationship between adolescent BMI and body dissatisfaction, both in males and females (Paxton et al., 1991). In this study, BMI was adjusted for normal changes in body proportion with age. Therefore, the present study used BMI as an indicator to classify persons who are underweight, normal weight, and overweight/obese.

The major non-pharmaceutical prevention and treatment for being overweight and obese includes dietary management and physical activity enhancement. The combination of these two moderators on life satisfaction remains to be determined.

Physical activity and life satisfaction

Great attention to physical activity has been paid as it prevents becoming overweight and improves the quality of life. Lines of evidence have showed that long term physical activity can improve fitness and bone health, and reduce the risks of chronic diseases (Booth, Gordon, Carlson, & Hamilton, 2000; Kemper et al., 2000). However, very few studies have focused on the effect that physical activity has on adolescent populations because adolescents are generally considered healthy.

Daily changes in physical activity imply great changes in overall health at any age. Research has showed that even small changes in daily physical activity between the ages of 18 to 89 years may have a great impact on life satisfaction (Maher, Pincus, Ram, & Conroy, 2015). The small changes in daily life include taking the stairs instead of the elevator and walking rather than taking the bus, especially in adulthood. Zullig et al. conducted a research stuey with students of grades 7 and 8, and showed that life satisfaction was significantly lower for both males and females who reported not playing on sports teams (Zullig & White, 2011). A recent research study suggested that middle-school girls who participated in organized soccer games rated their life satisfaction and subjective health more favorably than those who did not participate the soccer games (Wold et al., 2013). In addition, the relationship between the participation in physical activity and improved academic performance has been well established (Field, Diego, & Sanders, 2001). Physical activity has also been found to reduce the use of tobacco, alcohol, and drugs, to discourage bullying, and to promote social interaction (Samuelson, 2004), which in turn may enhance life satisfaction.

In this study, we hypothesized that physical activity correlates with BMI negatively, and with academic achievement and life satisfaction positively.

Eating behaviors and life satisfaction

In addition to physically active behaviors, eating habits play important roles in adolescent health and life satisfaction. Dietary habits can be formed during childhood and continue in adolescence throughout adulthood.

Previous research has demonstrated that obesity is correlated with the intake of poor nutrient food that is highly energy-dense, such as sweet biscuits and soft-drinks, whereas a diet high in fruit and vegetables helps to protect against obesity (Carlson, Crespo, Sallis, Patterson, & Elder, 2012; Swinburn, Caterson, Seidell, & James, 2004). An investigation developed by Hardy et al. (2012) reported that approximately half of Australian students in grades 6, 8, and 10 had low physical activity, high soft drink consumption, and high snack intake (Hardy et al., 2012). Some other studies showed that most of adolescents met recommendations for daily physical activity, but many of them did not meet nutritional guidelines when it comes to high fiber consumption, such as fruit and vegetables, and energy-dense foods ("2010 Dietary Guidelines. Updated recommendations put focus on obesity," 2010; American Academy of Pediatrics. Committee on Public, 2001; Menschik, Ahmed, Alexander, & Blum, 2008).

The research that has investigated the associations of fruit and vegetable intake with subjective well-being in Western countries reported inconsistent results. For example, a longitudinal study showed no effect on life satisfaction when they administered a dietary intervention with more fruits and vegetables and low fat foods (Corle et al., 2001). In another study, increased fruit and vegetable consumption lead to an improvement in health related quality of life (Steptoe, Perkins-Porras, Hilton, Rink, & Cappuccio, 2004).

The World Health Organization (WHO) has pointed out that physical activity interacted positively with strategies to improve diet (Organization, 2008). However, little

research has examined the relationships between life satisfaction and a variety of health behaviors. To my knowledge, no studies have ever tested the relationships among the combination of these obesogenic behaviors, academic achievement, and life satisfaction. Therefore, this study was aimed to explore the relationships among eating habits, physical activity, self-reported health, academic achievement, and life satisfaction among adolescents through a proposed structural equation model (SEM). This has crucial implications for public health because understanding what behaviors should be targeted to prevent obesity, and what factors have more influence on the academic achievement, health, and life satisfaction, would develop a high quality of life in adolescents, both from objective and subjective perspectives.

Structural equation modeling

Structural equation modeling (SEM) is a series of statistical methods that incorporate complex relationships between independent variables and dependent variables. It can be used to answer research questions involving direct or indirect observations simultaneously. Due to the complexity of SEM, multiple regressions are more common and simpler to be used for an investigation involving associations among different variables. However, SEM is more comprehensive as compared with multiple regressions, path analysis, and factor analysis. It is a hybrid between regression and factor analysis. SEM contains two main components, the measurement model and the structural model. The measurement model is when each observed item/variable is directly influenced by its latent construct. The structural model explains directional hypotheses among the latent variables of interest.

In our project, SEM was more appropriate than other methods. First, our data contains more than one independent and dependent variable. Second, the purpose of the present study was to investigate the relationships between variables simultaneously. Additionally, an unobserved construct, referred to as a latent variable, was included in our model. Moreover, meeting the strict assumptions of multiple regressions is usually not practical or possible. Although SEM has some assumptions, they are not as strict as in the regression model, such as identical and independent distributed observations. Last but not least, SEM can incorporate measurement error whereas that is not directly the case with multiple regressions.

Methodologies

Samples

Data were obtained from the Health Behavior in School-Age Children (HBSC), 2001-2002. This is a school-based study focusing on health-related attitudes and behaviors in young people. In the dataset, adolescents were recruited from grades 6 to 9. They were asked questions about physical activity, nutritional intake, alcohol and tobacco use, relationships with family and friends, perceptions of school and community, and violence, etc. Data was collected by the United States Department of Health and Human Services in collaboration with the World Health Organization.

Data cleaning

Prior to running the primary analysis, duplicates were removed from the dataset. Histogram and Q-Q plots showed that all variables of interest were approximately normally distributed. Expectation maximization (EM) was used to estimate values for missing data in IBM SPSS Statistics 19. A total of 14477 participants were included in the data analysis.

Variables

The scores of life satisfaction ranged from 0 to 10 indicating how satisfied students feel with their life. The score of 0 indicates the worst possible life the students feel, whereas the score of 10 indicates the best possible life the students feel. The score of academic achievement ranged from 1 to 4. Higher scores revealed better academic performance compared to one's classmates. The score of health also ranged from 1 to 4.

Higher scores suggest healthier lives. The value of BMI was normalized to age and gender, and recoded based on the percentiles from the year 2000 from the Center for Disease Control as follows: underweight (< 5^{th} percentile); healthy weight (between 5^{th} and 85^{th} percentile); overweight (between 85^{th} and 95^{th} percentile); and obese (> 95^{th} percentile). In the other variables of interest, such as physical activity, fruits, vegetables, breakfast, and coke drink, scores showed how many days per week students usually participated in those behaviors.

Statistical analysis

The relationships between health-related behaviors and life satisfaction were modeled using a series of multiple linear regressions in SPSS 19. R-squared values were used to assess explained variance in the outcome variables and to interpret the respective effect sizes. Structural equation modeling was conducted using AMOS 7.0. The results were interpreted using SEM and compared with the results from the regression models.

The SEM was drawn based on the previous research and logic. Rectangles represent measured variables, and ovals represent unmeasured or latent variables. Residuals ("e" in the circle) represent all the other influences on an endogenous variable in addition to those included in the model. To assess the overall model fit, root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR) were examined. Values greater than .90 in CFI and TLI are acceptable and values greater than .95 indicate good fit to the data (Hu & Bentler, 1999). Values lower than .05 in SRMR and RMSEA

generally reflect good model fit (Hu & Bentler, 1999). Due to the large sample size, chi-square was always significantly regardless how good the model fit the data.

Results

Descriptive Statistics

A total of 14477 participants were included in this study ranging in age from 10 to 17 years (M = 13.3, SD = 1.56). Of all the participants, 52.1% were girls and 47.9% were boys. The mean and standard deviation for all the variables of interest are displayed in Table 1. The results revealed that students on average reported moderate to high life satisfaction (M = 7.47, SD = 2.03), and good health (M = 3.02, SD = .73). The scores of variables related to the eating habits indicated how often students had vegetables, fruits, breakfast, and drank coke or soft drinks per week. In Table 1, it can be seen that the average number of days of having breakfast, fruits, and vegetables was around 4 days per week, and the average number of days drinking coke/soft drinks was about 5 days.

Inter-correlations

The inter-correlations for all variables of our interest are shown in Table 2. The results displayed that the relationships among all variables, except for the relationship between physical activity and soft drink, were significantly correlated each other. Due to the very large sample size and power, it is not surprising to observe many significances. Life satisfaction was positively correlated with physical activity, health, academic achievement, breakfast, fruits, and vegetables, and was negatively associated with BMI and soft drinks significantly. Vegetables and fruits showed moderate to strong correlation, r = .477. The correlation matrix also indicates that health was moderately associated with BMI (r = -.208) and academic achievement (r = .228). Additionally,

variance inflation factor (VIF) and tolerance were tested and showed that there were no multicollinearity between variables.

Structural Equation Modeling

A measurement model associated with eating habits was first tested to determine the model fit. The measurement model indicated good model fit, CFI = .976, TLI = .945, RMSEA = .034, SRMR = .019. Also, factor loadings were all significant. Similar to the inter-correlations, these significances were expected due to the large sample size. The factor loading on the breakfast was strongest whereas the loading on the soft drinks was weakest. According to previous research, theory, and logic, a final model was conducted by combining measurement and structural models, and it indicated a good model fit, CFI = .976, TLI = .945, RMSEA = .034, SRMR = .019. Figure 1 shows an overall SEM. Fruits and vegetables were moderately to strongly associated with each other, $\beta = .38$. An increased frequency in physical activity was related to healthier eating habits, $\beta = -.28$. All the other values on the direction lines represent the standardized coefficient β.

The direct, indirect, and total effects on adolescent life satisfaction are displayed in Table 3. Using the bootstrapping procedure in AMOS 7.0, the results indicated that life satisfaction was significantly predicted by eating habits, physical activity, BMI, health, and academic achievement indirectly. Specifically, a higher frequency in physical activity ($\beta = .017$) and better health ($\beta = .017$) resulted in better life satisfaction, whereas poor eating habits ($\beta = -.146$) and higher BMI indicative of greater body weight ($\beta = -.048$) led to lower life satisfactions. In the present study, higher BMI implied being overweight or

obese. A good habit of diet indicates having more vegetables and fruits, having breakfast more frequently, and drinking less coke/soft drinks. The results also revealed that BMI, health, and academic achievement had significant direct effects on the life satisfaction which were positive. Also, poor eating habits may cause lower levels of life satisfaction directly, $\beta = -.186$. Interestingly, physical activity had little direct effect on life satisfaction, $\beta = .01$. Among all variables, health seems to play the most important role on life satisfaction directly, $\beta = .295$. When it comes to the total effect, however, both health and eating habits demonstrated moderate to strong impacts on life satisfaction oppositely, $\beta = .311$ and $\beta = -.332$. Academic achievement and physical activity showed significantly positive total effects on life satisfaction, whereas BMI had negatively total effect on life satisfaction.

The direct, indirect, and total effects on adolescent academic achievement are shown in Table 4. Eating habits and physical activity had negative direct effects on the academic achievement, $\beta = -.289$ and $\beta = -.026$, whereas BMI and health had positive direct effects on the academic achievement, $\beta = .019$ and $\beta = .128$. All these variables, except for BMI, also showed significant total effects on the academic achievement. Similarly, Table 5 and Table 6 display the direct, indirect, and total effects on adolescent health and BMI, respectively. The results revealed that eating habits, physical activity, and BMI had substantial influences on health, in which BMI was also impacted by poor eating habits and low frequency in physical activity.

Multiple linear regressions

A series of multiple linear regressions were conducted to examine the effects of predictors on different dependent variables. For the life satisfaction shown in Table 7, the overall model was significant, $p < .001$. Of all the predictors, physical activity, breakfast, fruits, health, and academic achievement were significant positive predictors on the life satisfaction. However, BMI, Coke, and vegetable were not significant predictors. For model 2, academic achievement was significantly predicted by most variables except BMI. With respect to the health shown in model 3 of Table 7, physical activity, BMI, and health-related behaviors were significant predictors. Lower BMI and reduced frequency of drinking coke predicted better health. In model 4, the results showed that the overall model was significant, $p < .001$, but only physical activity, breakfast, and vegetables were significant negative predictors on BMI.

Table 1. Descriptive Statistics for health-related variables and life satisfaction

	Minimum	Maximum	Mean	Std. Deviation
Age	10	17	13.30	1.56
Physical activity	0	7	4.21	2.19
Breakfast	1	6	3.96	2.06
Fruits	1	7	4.29	1.68
Vegetables	1	7	4.24	1.75
Coke/soft drink	1	7	4.90	1.89
BMI	1	4	2.37	.71
Health	1	4	3.02	.73
Academic achievement	1	4	2.83	.86
Life Satisfaction	0	10	7.47	2.03

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Boy	6928	47.9	47.9	47.9
Girl	7549	52.1	52.1	100.0
Total	14477	100.0	100.0	

Table 2. Inter-correlations of the variables

	1	2	3	4	5	6	7	8	9
1. Physical activity	1								
2. BMI	-.067*	1							
3. Health	.164**	-.208**	1						
4. Academic achievement	.074*	-.043*	.228**	1					
5. Life Satisfaction	.119*	-.076*	.392**	.257**	1				
6. Breakfast	.092*	-.074*	.182**	.137*	.191*	1			
7. Fruits	.162**	-.030*	.160**	.130*	.12*	.186**	1		
8. Vegetables	.147**	-.049*	.125*	.126*	.097*	.153**	.477**	1	
9. Soft drinks	.011	.026*	-.048*	-.102*	-.043*	-.108*	-.076*	-.081*	1

*p≤.05. **p≤.01.

Table 3. Direct, indirect, and total effects on adolescent life satisfaction

Variables	Direct	Indirect	Total
Eating habits	-0.186**	-0.146*	-0.332*
Physical activity	0.010	0.017*	0.027*
BMI	0.016*	-0.048*	-0.032*
Health	0.295**	0.017*	0.311**
Academic achievement	0.129*		0.129*

*p≤.05. **p≤.01.

Table 4. Direct, indirect, and total effects on adolescent academic achievement

Variables	Direct	Indirect	Total
Eating habits	-0.289**	-0.043*	-0.332**
Physical activity	-0.026*	0.008*	-0.018*
BMI	0.019*	-0.048*	-0.002
Health	0.128*		0.128*

*p≤.05. **p≤.01.

Table 5. Direct, indirect, and total effects on adolescent health

Variables	Direct	Indirect	Total
Eating habits	-0.338**	-0.019**	-0.357**
Physical activity	0.060*	0.006*	0.066*
BMI	-0.160**		-0.160**

*p≤.05. **p≤.01.

Table 6. Direct, indirect, and total effects on adolescent BMI

Variables	Direct	Indirect	Total
Eating habits	0.119*		0.119*
Physical activity	-0.034*		-0.034*

*p≤.05. **p≤.01.

Table 7. Multiple linear regression models

Model	Dependent variable	R Square	Adjusted R Square	F	Sig.
1	Life satisfaction	.196	.195	439.504	.000

Independent variable	Beta	t	Sig.
Physical activity	.038	4.990	.000
Breakfast	.100	12.909	.000
Fruits	.018	2.091	.037
Vegetables	.007	.849	.396
Coke/Soft Drinks	.000	-.053	.958
BMI	.011	1.445	.148
Health	.328	40.924	.000
Academic achievement	.163	21.047	.000

Model	Dependent variable	R Square	Adjusted R Square	F	Sig.
2	Academic achievement	.077	.076	171.870	.000

Independent variable	Beta	t	Sig.
Physical activity	.020	2.456	.014
Breakfast	.074	8.886	.000
Fruits	.047	5.060	.000
Vegetables	.059	6.498	.000
Coke/Soft Drinks	-.077	-9.503	.000
BMI	.012	1.509	.131
Health	.195	23.188	.000

Model	Dependent variable	R Square	Adjusted R Square	F	Sig.
3	Health	.100	.099	266.960	.000

Independent variable	Beta	t	Sig.
Physical activity	.119	14.827	.000
Breakfast	.133	16.368	.000
Fruits	.094	10.300	.000
Vegetables	.031	3.386	.001
Coke/Soft Drinks	-.020	-2.516	.012
BMI	-.179	-22.575	.000

Table 7. (continuous) Multiple linear regression models

Model	Dependent variable	R Square	Adjusted R Square	F	Sig.
4	BMI	.011	.011	32.594	.000

Independent variable	Beta	t	Sig.
Physical activity	-.060	-7.171	.000
Breakfast	-.066	-7.738	.000
Fruits	.007	.725	.468
Vegetables	-.034	-3.585	.000
Coke/Soft Drinks	.015	1.798	.072

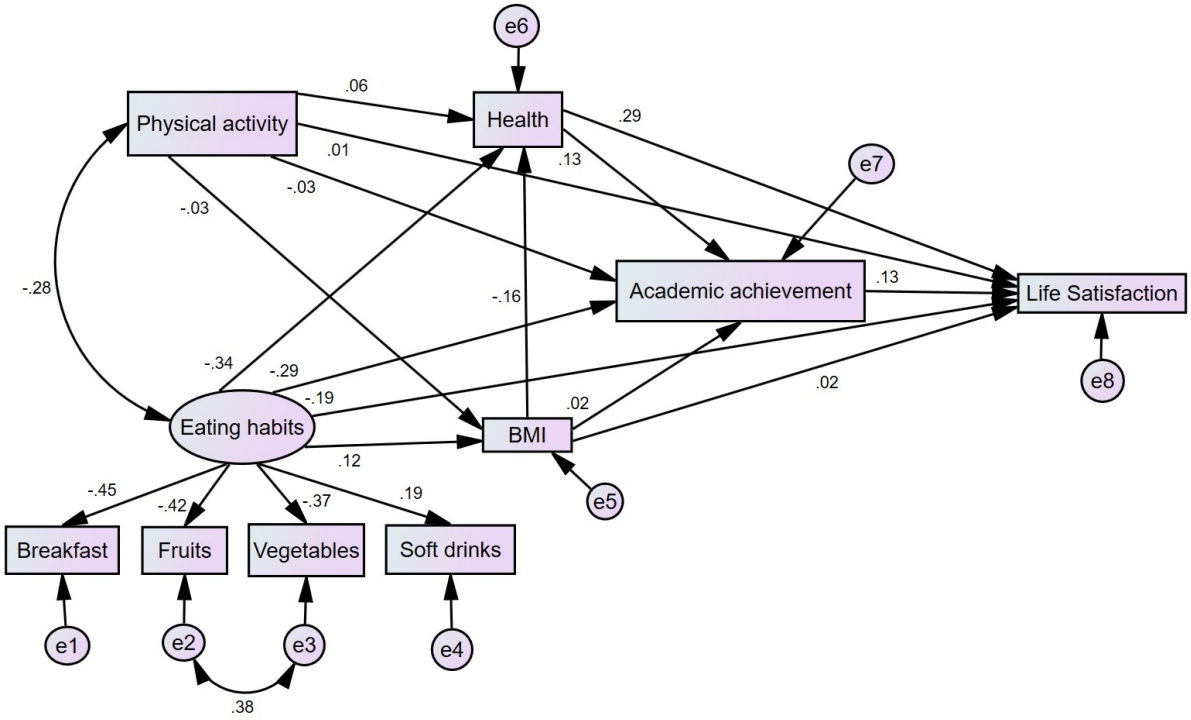


Figure 1. Structural equation modeling for adolescent life satisfaction

Discussion

Nowadays, improving adolescents' life satisfaction deserves great attention. Therefore, building resources for predicting wellness is important. The present study extended the existing literature that investigates the possible influence of health-related factors on adolescent life satisfaction. The primary findings were that healthier eating habits, more frequent/active physical activities, lower BMI, and improving self-reported health as well as academic achievement, significantly promoted a higher score of life satisfaction. This was the first study to investigate the associations among adolescent health behaviors, academic achievement, and life satisfaction in SEM.

Pediatric recommendations suggest that increasing frequency in physical activity and improving diet quality are crucial during childhood and adolescence because establishment of healthful patterns during adolescence can track to adulthood (Expert Panel on Integrated Guidelines for Cardiovascular, Risk Reduction in, Adolescents, National Heart, & Blood, 2011; Hallal, Victora, Azevedo, & Wells, 2006).

Early studies have reported that frequent physical activity was relevant to increased life satisfaction. The present study supported previous research showing that more frequent physical activity in general lead to a better life satisfaction, but physical activity does not appear to impact life satisfaction directly. Instead, the relationship between physical activity and life satisfaction was mediated by BMI, health, and academic achievement. Also, according to previous research, it was likely that physical activity results in higher extrinsic values, such as a better body shape and image

experiences (Kirkcaldy, Shephard, & Siefen, 2002), which in turn enhances community feelings, improves health, and inspires self-acceptance and self-esteem. Overall, there was poor but acceptable relationship between physical activity and life satisfaction.

With regard to the eating habits, Iannotti and the colleagues have reported that a diet higher in energy-dense foods, such as sweets and coke, were positively associated with adiposity and metabolic syndrome that negatively related to psychological functioning (Iannotti & Wang, 2013). In the present study, the factor loading for item sweet on its latent construct eating habits was non-significant ($\beta < .01$), so this item was removed from SEM model. The results revealed that poor eating habits, in general, may directly reduce their life satisfaction. Poor eating habits may also increase BMI, impair health, and cause reductions in academic achievement, and eventually lead to life dissatisfaction. Among different items, fruits and vegetables were highly correlated each other beyond the eating habits factor. In agreement with other research, our findings indicate that eating habits are a crucial factor that influences adolescent life satisfaction.

Another purpose of this study was to compare different models on the results of life satisfaction. Multiple linear regressions are first generation multivariate methods, whereas SEM is a second generation multivariate method that can be used to assess the reliability and validity of the model measures. Overall, results generated from SEM and multiple linear regressions were very similar. The primary discrepancy was that of all eating-related behaviors, only fruits and breakfast performed significant predictions on life satisfaction in the regression model. Nevertheless, a latent variable, eating habits, was

created by 4 items in SEM, and illustrated a more crucial role predicting life satisfaction. Furthermore, there were slight differences in the standardized coefficients for the total effects between SEM and regression models due to the existing latent variable in SEM, but the general proportion of each variable accounted for the explanation drew the same conclusions. A series of relationships are analyzed by SEM simultaneously and by linear regression sequentially. Therefore, if SEM did not include a latent variable in the present study, total effects from both methods/software were expected to be same.

Despite the similarities between linear regression and SEM, it was preferable to choose SEM over multiple linear regressions in the current study for several reasons. One advantage for SEM is that this model is able to analyze the relationships between more than one outcome variable simultaneously, but the analyses have to be performed in sequential steps in linear regression. Also, measurement error is not additive in a residual error term in the SEM. Furthermore, SEM can generate latent variables leading to more accurate estimates. In the present study, eating habits, created and converged by several observed variables, is measured better than an aggregated variable because it account for errors in the individual items used to measure the factor in the SEM. Additionally, SEM provides more sophisticated information concerning the significance of mediation (indirect) effects.

Limitations

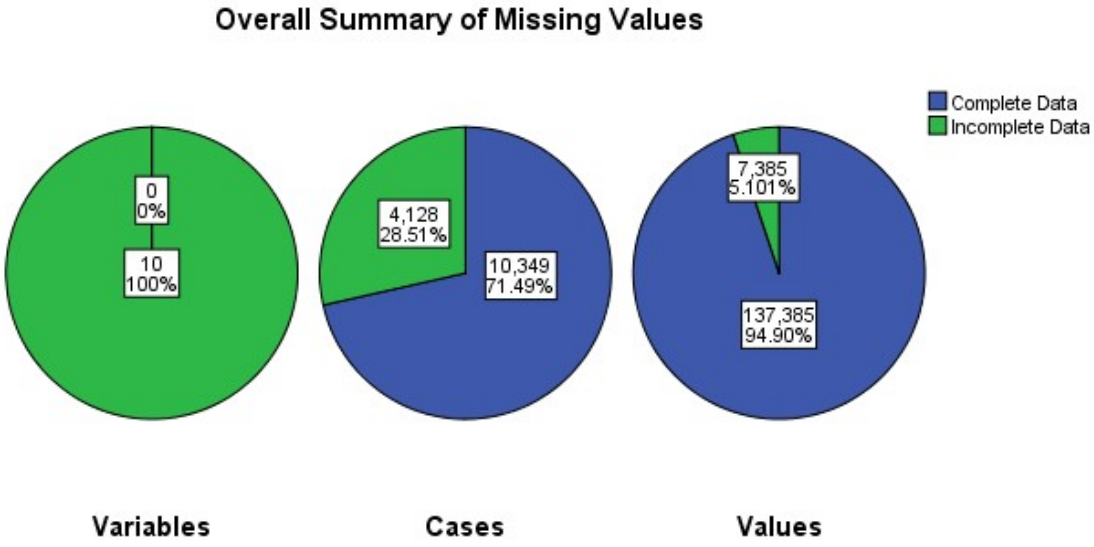
There are certain limitations for this study. First, this is cross-sectional study, so we cannot draw conclusions about causal relationships among the variables. Low life satisfaction may lead to low frequency of physical activity and poor eating habits. We also cannot rule out the possibility that other factors may predispose adolescent health-related behaviors and their life satisfactions. Second, all variables, except for academic achievement, were self-reported in this study. Some results may be overestimated. For example, students may overestimate frequency of physical activity. Data from subjective self-report seem to be always higher than objective measures. Moreover, this study only measured one time point, and assumed that all adolescents would develop into adults. Rate of suicide was not examined directly. Future longitudinal studies are needed to evaluate whether or not these variables predict the rate of suicide both in adolescents and adults.

Conclusions

Despite some limitations, our findings indicate that health plays a primary role on the prediction of adolescent life satisfaction. Healthy eating habits could directly drive a better life satisfaction, which effect can also be mediated by health. Additionally, BMI, physical activity, and academic achievement impact life satisfaction to different extent. Compared with multiple linear regressions, SEM is preferable to be used in the present study, for the fact that a latent construct can be created by several observed variables. Mediation is also easier to be detected by SEM.

Appendices

Appendix A. Missing data assessment



a. Little's MCAR test: Chi-Square = 2067.872, DF = 1387, Sig. = .000

Appendix B. Unstandardized coefficients and significances in SEM

Regression Weights

			Estimate	S.E.	C.R.	P
BMI	<---	Physical activity	-0.011	0.003	-3.682	***
BMI	<---	Eating habits	0.236	0.033	7.121	***
Health	<---	Physical activity	0.02	0.003	6.214	***
Health	<---	BMI	-0.168	0.009	-18.482	***
Health	<---	Eating habits	-0.699	0.055	-12.617	***
Academic achievement	<---	BMI	0.024	0.011	2.195	0.028
Academic achievement	<---	Physical activity	-0.01	0.004	-2.698	0.007
Academic achievement	<---	Health	0.151	0.013	11.968	***
Academic achievement	<---	Eating habits	-0.706	0.062	-11.364	***
Life Satisfaction	<---	Health	0.823	0.026	31.387	***
Life Satisfaction	<---	BMI	0.046	0.023	1.982	0.047
Life Satisfaction	<---	Academic achievement	0.305	0.021	14.455	***
Life Satisfaction	<---	Physical activity	0.01	0.008	1.194	0.233
Life Satisfaction	<---	Eating habits	-1.073	0.118	-9.107	***
Breakfast	<---	Eating habits	-2.657	0.189	-14.095	***
Fruits	<---	Eating habits	-2.025	0.146	-13.895	***
Vegetables	<---	Eating habits	-1.815	0.135	-13.474	***
Soft drinks	<---	Eating habits	1			

Appendix C. Standardized coefficients in SEM

Standardized Regression Weights

			Estimate
BMI	<---	Physical activity	-0.034
BMI	<---	Eating habits	0.119
Health	<---	Eating habits	-0.338
Health	<---	Physical activity	0.06
Health	<---	BMI	-0.16
Academic achievement	<---	Health	0.128
Academic achievement	<---	Physical activity	-0.026
Academic achievement	<---	Eating habits	-0.289
Academic achievement	<---	BMI	0.019
Soft drinks	<---	Eating habits	0.186
Vegetables	<---	Eating habits	-0.365
Fruits	<---	Eating habits	-0.423
Breakfast	<---	Eating habits	-0.453
Life Satisfaction	<---	Health	0.295
Life Satisfaction	<---	BMI	0.016
Life Satisfaction	<---	Academic achievement	0.129
Life Satisfaction	<---	Physical activity	0.01
Life Satisfaction	<---	Eating habits	-0.186

Appendix D. Raw data for standardized direct, indirect, and total effects

Standardized Direct Effects

	Eating habits	Physical activity	BMI	Health	Academic achievement
BMI	0.119	-0.034	0	0	0
Health	-0.338	0.06	-0.16	0	0
Academic achievement	-0.289	-0.026	0.019	0.128	0
Life Satisfaction	-0.186	0.01	0.016	0.295	0.129
Breakfast	-0.453	0	0	0	0
Fruits	-0.423	0	0	0	0
Vegetables	-0.365	0	0	0	0
Soft drinks	0.186	0	0	0	0

Standardized Indirect Effects

	Eating habits	Physical activity	BMI	Health	Academic achievement
BMI	0	0	0	0	0
Health	-0.019	0.006	0	0	0
Academic achievement	-0.043	0.008	-0.021	0	0
Life Satisfaction	-0.146	0.017	-0.048	0.017	0
Breakfast	0	0	0	0	0
Fruits	0	0	0	0	0
Vegetables	0	0	0	0	0
Soft drinks	0	0	0	0	0

Standardized Total Effects

	Eating habits	Physical activity	BMI	Health	Academic achievement
BMI	0.119	-0.034	0	0	0
Health	-0.357	0.066	-0.16	0	0
Academic achievement	-0.332	-0.018	-0.002	0.128	0
Life Satisfaction	-0.332	0.027	-0.032	0.311	0.129
Breakfast	-0.453	0	0	0	0
Fruits	-0.423	0	0	0	0
Vegetables	-0.365	0	0	0	0
Soft drinks	0.186	0	0	0	0

Appendix E. Model fit indices

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Model 1	38	286.543	16	0	17.909
Saturated model	54	0	0		
Independence model	18	11175.46	36	0	310.429

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Model 1	0.974	0.942	0.976	0.945	0.976
Saturated model	1		1		1
Independence model	0	0	0	0	0

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Model 1	0.444	0.433	0.434
Saturated model	0	0	0
Independence model	1	0	0

NCP

Model	NCP	LO 90	HI 90
Model 1	270.543	219.307	329.216
Saturated model	0	0	0
Independence model	11139.46	10795.12	11490.08

FMIN

Model	FMIN	F0	LO 90	HI 90
Model 1	0.02	0.019	0.015	0.023
Saturated model	0	0	0	0
Independence model	0.772	0.77	0.746	0.794

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Model 1	0.034	0.031	0.038	1
Independence model	0.146	0.144	0.148	0

References

2010 Dietary Guidelines. Updated recommendations put focus on obesity. (2010). *Mayo Clin Womens Healthsource, 14*(12), 1-2.

American Academy of Pediatrics. Committee on Public, E. (2001). American Academy of Pediatrics: Children, adolescents, and television. *Pediatrics, 107*(2), 423-426.

Barker, E. D., Arseneault, L., Brendgen, M., Fontaine, N., & Maughan, B. (2008). Joint development of bullying and victimization in adolescence: relations to delinquency and self-harm. *J Am Acad Child Adolesc Psychiatry, 47*(9), 1030-1038.

Blanchflower, D. G., & Oswald, A. J. (2008). Is well-being U-shaped over the life cycle? *Soc Sci Med, 66*(8), 1733-1749.

Booth, F. W., Gordon, S. E., Carlson, C. J., & Hamilton, M. T. (2000). Waging war on modern chronic diseases: primary prevention through exercise biology. *J Appl Physiol (1985), 88*(2), 774-787.

Brent, D. A., Baugher, M., Bridge, J., Chen, T., & Chiappetta, L. (1999). Age- and sex-related risk factors for adolescent suicide. *J Am Acad Child Adolesc Psychiatry, 38*(12), 1497-1505.

Bridge, J. A., Goldstein, T. R., & Brent, D. A. (2006). Adolescent suicide and suicidal behavior. *J Child Psychol Psychiatry, 47*(3-4), 372-394.

Carlson, J. A., Crespo, N. C., Sallis, J. F., Patterson, R. E., & Elder, J. P. (2012). Dietary-related and physical activity-related predictors of obesity in children: a 2-year prospective study. *Child Obes, 8*(2), 110-115.

Cash, S. J., & Bridge, J. A. (2009). Epidemiology of youth suicide and suicidal behavior. *Curr Opin Pediatr, 21*(5), 613-619.

Chang, L., McBride-Chang, C., Stewart, S., & Au, E. (2003). Life satisfaction, self-concept, and family relations in Chinese adolescents and children. *International Journal of Behavioral Development, 27*(2), 182-189.

Corle, D. K., Sharbaugh, C., Mateski, D. J., Coyne, T., Paskett, E. D., Cahill, J., et al. (2001). Self-rated quality of life measures: effect of change to a low-fat, high-fiber, fruit and vegetable enriched diet. *Ann Behav Med, 23*(3), 198-207.

Cowen, E. L. (1991). In pursuit of wellness. *American Psychologist, 46*(4), 404.

Cowen, E. L. (1994). The enhancement of psychological wellness: Challenges and opportunities. *American journal of community psychology, 22*(2), 149-179.

Diener, E. (1984). Subjective well-being. *Psychol Bull, 95*(3), 542-575.

Expert Panel on Integrated Guidelines for Cardiovascular, H., Risk Reduction in, C., Adolescents, National Heart, L., & Blood, I. (2011). Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. *Pediatrics, 128 Suppl 5*, S213-256.

Field, T., Diego, M., & Sanders, C. E. (2001). Exercise is positively related to adolescents' relationships and academics. *ADOLESCENCE-SAN DIEGO-, 36*, 105-110.

Forste, R., & Moore, E. (2012). Adolescent obesity and life satisfaction: perceptions of self, peers, family, and school. *Econ Hum Biol, 10*(4), 385-394.

Freedman, D. S., Mei, Z., Srinivasan, S. R., Berenson, G. S., & Dietz, W. H. (2007). Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. *J Pediatr, 150*(1), 12-17 e12.

Hallal, P. C., Victora, C. G., Azevedo, M. R., & Wells, J. C. (2006). Adolescent physical activity and health: a systematic review. *Sports Med, 36*(12), 1019-1030.

Hardy, L. L., Grunseit, A., Khambalia, A., Bell, C., Wolfenden, L., & Milat, A. J. (2012). Co-occurrence of obesogenic risk factors among adolescents. *J Adolesc Health, 51*(3), 265-271.

Horley, J. (1984). Life satisfaction, happiness, and morale: two problems with the use of subjective well-being indicators. *Gerontologist, 24*(2), 124-127.

Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal, 6*(1), 1-55.

Huebner, E. S., Funk, B. A., & Gilman, R. (2000). Cross-sectional and longitudinal psychosocial correlates of adolescent life satisfaction reports. *Canadian journal of school psychology, 16*(1), 53-64.

Iannotti, R. J., & Wang, J. (2013). Patterns of physical activity, sedentary behavior, and diet in U.S. adolescents. *J Adolesc Health, 53*(2), 280-286.

Kemper, H. C., Twisk, J. W., van Mechelen, W., Post, G. B., Roos, J. C., & Lips, P. (2000). A fifteen-year longitudinal study in young adults on the relation of

physical activity and fitness with the development of the bone mass: The Amsterdam Growth And Health Longitudinal Study. *Bone, 27*(6), 847-853.

Kirkcaldy, B. D., Shephard, R. J., & Siefen, R. G. (2002). The relationship between physical activity and self-image and problem behaviour among adolescents. *Soc Psychiatry Psychiatr Epidemiol, 37*(11), 544-550.

Klomek, A. B., Sourander, A., Niemela, S., Kumpulainen, K., Piha, J., Tamminen, T., et al. (2009). Childhood bullying behaviors as a risk for suicide attempts and completed suicides: a population-based birth cohort study. *J Am Acad Child Adolesc Psychiatry, 48*(3), 254-261.

Koivumaa-Honkanen, H., Honkanen, R., Viinamaki, H., Heikkila, K., Kaprio, J., & Koskenvuo, M. (2001). Life satisfaction and suicide: a 20-year follow-up study. *Am J Psychiatry, 158*(3), 433-439.

Leung, J. P., & Leung, K. (1992). Life satisfaction, self-concept, and relationship with parents in adolescence. *J Youth Adolesc, 21*(6), 653-665.

Li, C., Ford, E. S., Zhao, G., & Mokdad, A. H. (2009). Prevalence of pre-diabetes and its association with clustering of cardiometabolic risk factors and hyperinsulinemia among U.S. adolescents: National Health and Nutrition Examination Survey 2005-2006. *Diabetes Care, 32*(2), 342-347.

Maher, J. P., Pincus, A. L., Ram, N., & Conroy, D. E. (2015). Daily physical activity and life satisfaction across adulthood. *Dev Psychol, 51*(10), 1407-1419.

Menschik, D., Ahmed, S., Alexander, M. H., & Blum, R. W. (2008). Adolescent physical activities as predictors of young adult weight. *Arch Pediatr Adolesc Med, 162*(1), 29-33.

Moksnes, U. K., & Espnes, G. A. (2013). Self-esteem and life satisfaction in adolescents-gender and age as potential moderators. *Qual Life Res, 22*(10), 2921-2928.

Morganti, J. B., Nehrke, M. F., Hulicka, I. M., & Cataldo, J. F. (1988). Life-span differences in life satisfaction, self-concept, and locus of control. *Int J Aging Hum Dev, 26*(1), 45-56.

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). Prevalence of childhood and adult obesity in the United States, 2011-2012. *JAMA, 311*(8), 806-814.

Organization, W. H. (2008). School policy framework: implementation of the WHO global strategy on diet, physical activity and health.

Paxton, S. J., Wertheim, E. H., Gibbons, K., Szmukler, G. I., Hillier, L., & Petrovich, J. L. (1991). Body image satisfaction, dieting beliefs, and weight loss behaviors in adolescent girls and boys. *J Youth Adolesc, 20*(3), 361-379.

Raj, M., & Kumar, R. K. (2010). Obesity in children & adolescents. *Indian J Med Res, 132*, 598-607.

Samuelson, G. (2004). Global strategy on diet, physical activity and health. *Food & Nutrition Research, 48*(2), 57-57.

Schilling, E. A., Aseltine, R. H., Jr., Glanovsky, J. L., James, A., & Jacobs, D. (2009). Adolescent alcohol use, suicidal ideation, and suicide attempts. *J Adolesc Health, 44*(4), 335-341.

Shaffer, D., Gould, M. S., Fisher, P., Trautman, P., Moreau, D., Kleinman, M., et al. (1996). Psychiatric diagnosis in child and adolescent suicide. *Arch Gen Psychiatry, 53*(4), 339-348.

Steptoe, A., Deaton, A., & Stone, A. A. (2015). Subjective wellbeing, health, and ageing. *Lancet, 385*(9968), 640-648.

Steptoe, A., Perkins-Porras, L., Hilton, S., Rink, E., & Cappuccio, F. P. (2004). Quality of life and self-rated health in relation to changes in fruit and vegetable intake and in plasma vitamins C and E in a randomised trial of behavioural and nutritional education counselling. *Br J Nutr, 92*(1), 177-184.

Stone, A. A., Schwartz, J. E., Broderick, J. E., & Deaton, A. (2010). A snapshot of the age distribution of psychological well-being in the United States. *Proc Natl Acad Sci U S A, 107*(22), 9985-9990.

Suldo, S. M., & Huebner, E. S. (2004). The role of life satisfaction in the relationship between authoritative parenting dimensions and adolescent problem behavior *Quality-of-Life Research on Children and Adolescents* (pp. 165-195): Springer.

Swinburn, B. A., Caterson, I., Seidell, J. C., & James, W. P. (2004). Diet, nutrition and the prevention of excess weight gain and obesity. *Public Health Nutr, 7*(1A), 123-146.

Wold, B., Duda, J. L., Balaguer, I., Smith, O. R. F., Ommundsen, Y., Hall, H. K., et al. (2013). Comparing self-reported leisure-time physical activity, subjective health, and life satisfaction among youth soccer players and adolescents in a reference sample. *International Journal of Sport and Exercise Psychology, 11*(4), 328-340.

Zullig, K. J., & White, R. J. (2011). Physical activity, life satisfaction, and self-rated health of middle school students. *Applied Research in Quality of Life, 6*(3), 277-289.